Dynamically Adaptable Component-based Data Link Systems (DACDLS)

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DASADA Winter PI Meeting

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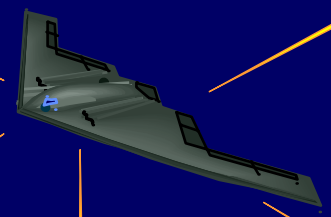
Program Goals



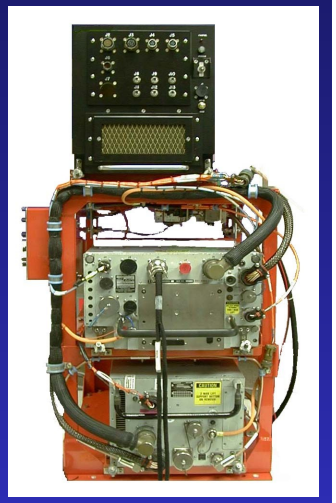
- **Demonstrate DASADA Technologies To Enable:**
  - **Adaptive In-flight Replanning And Retargeting**
  - **Dynamic In-Theater Sensor/Shooter Integration**

Approach

Phase I
Technology Development

B-2 JEFX99/00 Data Link Application Reengineered to Use Gauges to Control Dynamic Composition and Reconfiguration

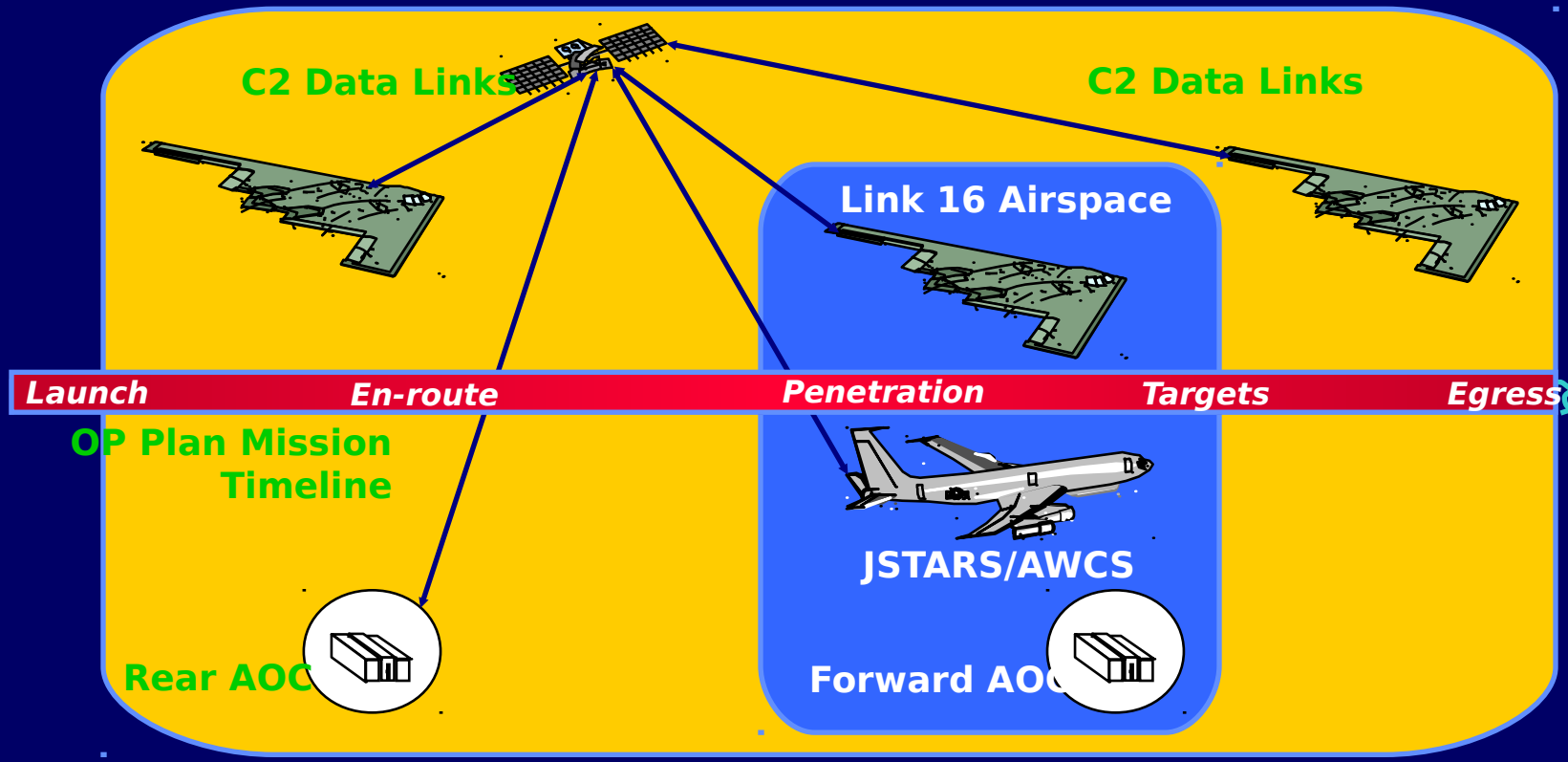
Phase II
Service-Led Experimental Demonstration



B-2 JEFX Data Link Application, Running on Flight Hardware, Demonstrating Ability to Use Gauges to Control Dynamic Composition and Reconfiguration of In-Flight Avionics

- **Build On Successful B-2 JEFX99 Demonstration**
  - **Demonstrated B-2 Flexible Re-Targeting**
  - **Government Owned Flight Operational Hardware**

Demonstration Scenario

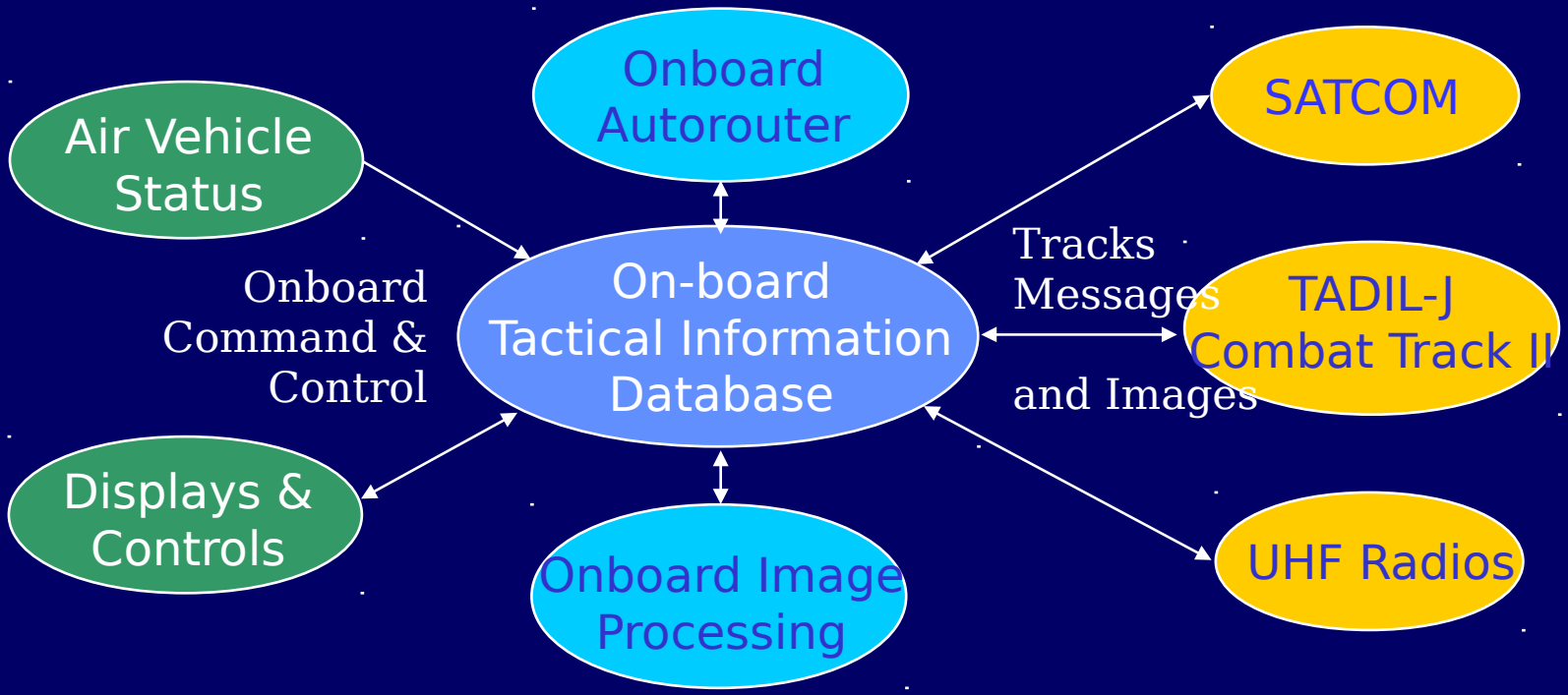


- Rapid Launch With Minimum Mission Plan
- Adapt In-Theater To Prosecute A Collection of Time Critical Targets

Technical Approach

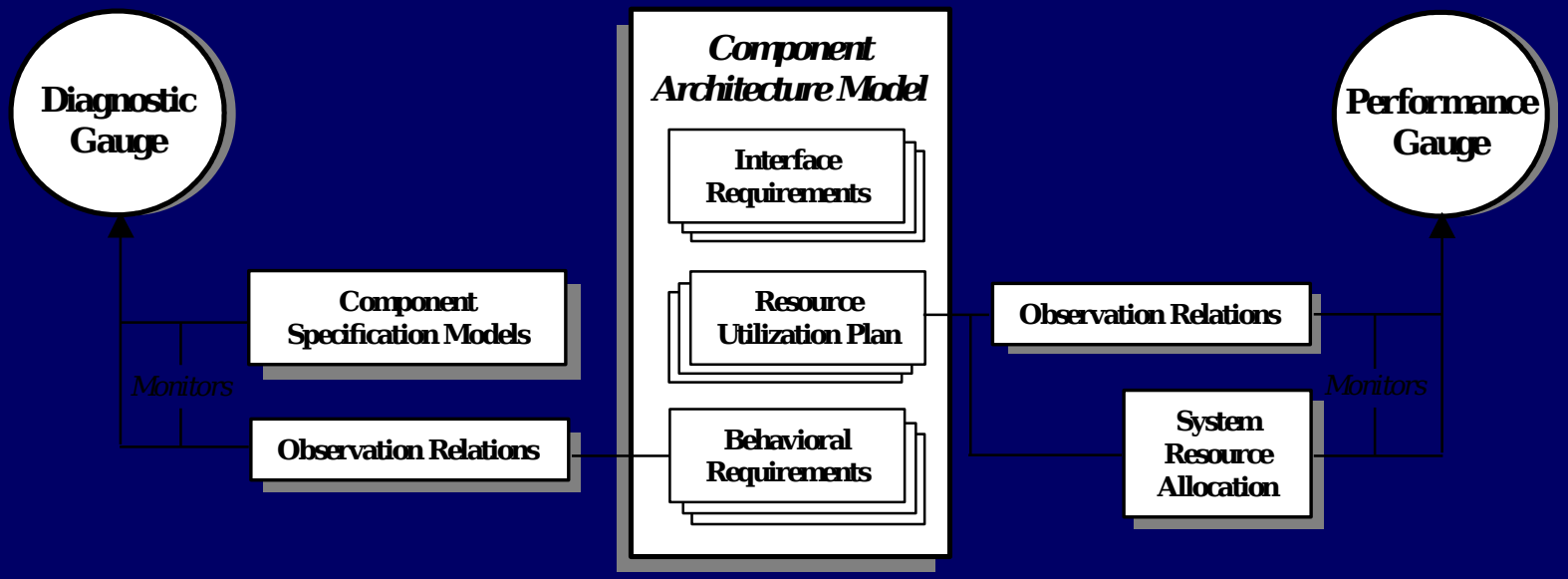
- **Work With Resource Constrained Systems Group To Address Four Key Technology Areas:**
  - **Rapid Dynamic Component Assembly**
  - **Comprehensive System Analysis (i.e., timing, safety, reliability, security)**
  - **Real-time Resource Management (under constraints)**
  - **Heterogeneous Interacting Resource Allocation Policies**
- **Assess Impact Of Various Group Capabilities Within The Scope Of Several Demonstrations**

Dynamic Component Assembly



- **Candidate Components Selected To Meet Mission Requirements**
- **Specification-based Model Testing Approach Measures Compliance To Architectural Model**

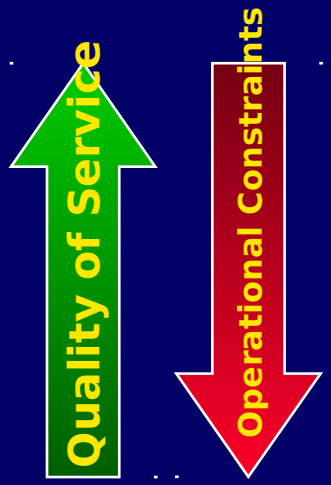
System Analysis



- Gauges Quantify Divergence of Component's Predicted Behavior To Actual Performance
  - Divergence Beyond Setpoints Triggers Repair Strategies
- Components Must Be Configured To Continually Meet Constraints of Theater of Operation

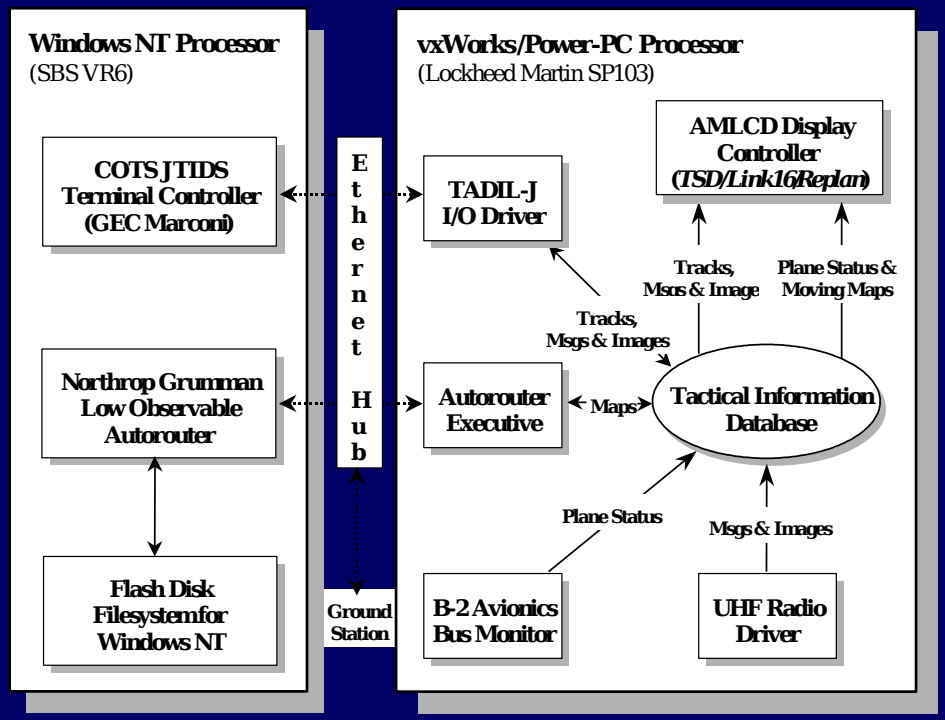
Real-time Resource Management

- **Three Candidate Methods To Determine Air Vehicle Navigation Data**



  - Access Navigation Data (Location, Heading, and Speed) from Flight Computer
  - Augment GPS with Heading From Onboard INS
  - Acquire Location Data From GPS
- **Operational Constraints Restrict Resource Usage**
  - **e.x., Flight Computer Cannot Be Accessed If Transmitting via Link-16/Combat Track II**
- **System Must Adapt As Operational Constraints Change**

Resource Allocation



Two Classes of Resource Allocation Problems

- Workload Allocation Between Processors
- Discovery/Allocation of Spare (Slack) Resources on Each Processor

- Take Advantage of Computational Resources
  - Image Enhancement / Sensor Fusion
- Reallocate Workload To Ensure Task Completion

Capabilities Being Produced

- **We will Produce Gauges Based Upon:**
  - **T-VEC - Use Specification-based Model Testing Approach To Measure A Component's Compliance To Architectural Model**
  - **CEP (Complex Event Processing) To Provide Rich Event-based Infrastructure for Creation and Management of Probes Required To Monitor the Operational System**

Capabilities Being Consumed

- Will Explore The Use of Meta H As Basis For Consumption/Performance Gauges
  - Slack Scheduler / Reliability Model
- Interested In Time Wiz++ / Meta H Interaction in Terms of
  - Quality of Service Assessment
  - Addition of Time Wiz++ Real-Time Queue Theory Work to Meta H
- Will Evaluate Runtime Monitoring Approaches Using Both Meta H And CEP Event Triggers

Capabilities Being Consumed

- A Number of Modeling Languages (ADLs) Will Be Consumed
  - ACME/Armani To Model Component Composition Constraints
  - Meta H To Model Component Performance Characteristics
  - ArchRepair To Model Explicit Recovery Architectures
- A Major Issue Will Be ADL Interoperability
  - What Semantics Are Lost During Translation And What Is The Impact

Demo Days 01 Goals

- Focus of Demo is Component Composition
  - Combines Formal Testing Approach With Resource Allocation Prediction/Measurement
  - Evaluate Ability Of Various ADLs To Model Behavior And Resource Requirements
- Composition On A Heterogeneous Target Platform
  - Impact Of Varying Computation Resources On System Composition
    - Multiple CPUs vs. Inter-Processor Communications Costs
  - Modeling Redundancy - Safety vs. Performance Considerations

Demo Days 01 Goals (Cont.)

- Assess Trade-off Between Various Real-Time Scheduling Approaches
  - Can One Determine Whether Rate-Monotonic Scheduling Is Required (Quality of Service)?
  - Impact Of Components Requiring Some Level Of Assured Asynchronous Scheduling?
  - How Does One Measure/Model Impact Of (And Recover From) Inadequate Schedule Slack?
- Impact Of Monitored System - Probe Insertion
  - Evaluate Various Probe Approaches And Impact On Predicted Performance
  - How Much Useful Information Is Available From Slack Scheduled Probes?

DACDLS: Dynamically Adaptable Component-based Data Link Systems

New Ideas

- Measure component's ability to function within a system through specification-based testing of its conformance to formal architectural model of system
- Combine this metric with measurement of component's resource consumption to select optimal candidate
- Automatically generate gauges to measure component's run-time compliance to architectural model
- Detect and respond to real-time resource starvation through corrective system reconfiguration/tailoring

Impact

- New paradigm for the creation and operation of real-time mission critical avionics systems:
  - Black-box avionics replaced with tailorable component-based avionics that adapt to dynamic changes in mission requirements
  - Component libraries enable adaptations to be dynamically shared among mission assets
  - In-flight reconfiguration enables rapid response to highly dynamic theaters of operation

Schedule

1. Baseline Architectural and Target Execution Platform Models
2. Configuration Strategy Engine Infrastructure
3. Assembly Gauges
4. Consumption Gauges
5. Diagnostic Gauges and Reconfiguration Engine
6. Performance Gauges

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